BIOLOGICAL NOTES UPON THE FIREBRAT, THERMOBIA DOMESTICA PACKARD[1]

By J. A. Adams

ABSTRACT

Firebrats were reared at 37° C. The cycle from egg to egg was completed in about eleven weeks. Growth and molting continue after sexual maturity. Rolled oats and beef are suitable food. Development was more rapid when water was provided. The eggs and tiny nymphs are highly resistant to dessication.

The firebrat, common as it is, has been given scant attention by entomologists. Packard described it in 1873, placing it in the Linnean genus Lepisma. Bergroth (1890) removed it to Thermobia from an invalid genus, Thermophila. The early economic entomologists mentioned it in their reports without proposing any adequate control. It has remained for Spencer (1929 and 1930) to investigate the life history and reactions. The bulk of his work has not, to the writer's knowledge, appeared. Wakeland and Waters (1931) have worked out what promises to be the first satisfactory method of control. Space does not suffice to list the histological and other works which have been done upon Thermobia.

Preliminary life history studies have been undertaken and the present paper intends to present facts which may be of interest to other workers. Results of a more detailed study will appear subsequently.

The inability of the firebrat to climb upon vertical glass or metal surfaces renders it fairly easy to trap and to confine. Its habit of living under the even conditions of dark, warm cellars seems to make easy its transition to apparatus of constant temperature and humidity. Rearings were made in such apparatus as is described by Brindley and Richardson (1931) at 37° C. and 50 to 70 per cent relative humidity. The insects were kept in battery jars containing folded paper or fragments of clay pots. Water was provided upon cotton wicks fed from glass

[1] Contribution from the Department of Zoölogy and Entomology, Iowa State College, Ames, Iowa.

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containers. Food was placed in the jars in small paper boxes. The eggs were conveniently collected since the insects oviposit readily into wads of cotton batting. The jars were left uncovered and the air within the cabinet kept in constant motion. The jars were shielded from the direct rays of the heating filament.

THE EGG

The newly laid egg is pearly white, becoming creamy white upon exposure. It is elliptical in long section and circular in cross section. It weighs about .3 mg. Six eggs from one female had an average long diameter of .98 mm. and an average short diameter of .78 mm. The first ten eggs taken from a colony of about 290 individuals just beginning to reproduce averaged 1.00 × .77 mm. Twenty-five eggs laid on the same day in a breeding jar containing numerous females of considerable age averaged 1.09 × .77 mm. The shortest measured .97 × .76 mm.; the longest 1.29 × .75 mm. and the broadest 1.00 × .83 mm. The greater constancy of the short diameter may be attributed to the limitations of the oviducal structures. Eggs of odd shapes were found where oviposition occurred in crevices, often having flattened forms suggestive of Irish potatoes. The eggs are scarcely adhesive. The chorion of turgid newly laid eggs is shiny and smooth with sparse minute markings. The chorion of partially dessicated or incubated eggs is granular in appearance. Although the hatching of hundreds of eggs has been recorded no clear case of infertility or diapause has been found.

The period of incubation at 37° C. is from fourteen to eighteen days, with most eggs hatching in fifteen days. Eggs were hatched in small glass dishes over humidity controlling solutions of potassium hydroxide, sodium chloride and magnesium chloride. The hatching time seems to be about the same at low and high humidities. It is interesting to note that 10 eggs incubated at 30 per cent relative humidity hatched 10 evidently healthy nymphs.

NYMPHS

In the last few days of incubation the curled embryo, with its dark ommatidia, is readily visible through the chorion. The nymph emerges, head first, from an irregular rupture through one end of the chorion. Newly hatched nymphs are waxy white,

about .6 mm. in width and 2.1 mm. in length, omitting appendages. They present a more primitive appearance than the mature form. The body is without scales and the appendages are relatively short. The heart beat can be readily observed and after feeding commences the darkened bolus of food is visible within the animal. The first molt occurs in about two days. The number of molts is evidently indefinite. With successive molts, scales, genitalia, styli, and mature proportions appear.

Reproduction begins well before the individual has reached maximum body weight. In a colony of about 245 growing nymphs, eggs were first found when the average weight of the nymphs was 9.2 mg. It must not be assumed that this is an average body weight for sexual maturity since some nymphs were much larger than others. In general at 37° C. the cycle from egg to egg was 11 to 12 weeks. Egg laying is continued for a period not yet defined. A number of old females have been ovipositing for five months. One female laid 25 eggs in 23 days.

Maximum body weight appears to be attained about two months after sexual maturity. The firebrats reared under favorable controlled conditions of temperature and humidity attain sizes seldom seen in specimens under ordinary circumstances. Five females, which had been regarded as fully grown for three months and which had been fertile, weighed from 25.3 to 34.5 mg. The males which belonged to the same lot and which had been confined with these females varied in weight from 16.4 to 29.5 mg.

The firebrat females are evidently highly sensitive to disturbance. In a colony of about 150 males and females the following record of egg production was obtained:

April 7th–11th—Not disturbed in interval, 205 eggs.
April 12th–16th—Daily disturbed in interval, 9 eggs.
April 17th–21st—Not disturbed in interval, 70 eggs.
April 22d—Not disturbed in interval, 22 eggs.
April 23rd–May 3rd—Not disturbed in interval, 112 eggs.
May 4th–8th—Not disturbed in interval, 110 eggs.
May 9th–18th—Daily disturbed in interval, 24 eggs.
May 19th–24th—Not disturbed in interval, 260 eggs.

There are not adequate data for a statement upon the sex ratio. In most populations counted the females have outnumbered the males.

The molting firebrat emerges from a mid-dorsal cleft of its skin extending the length of the thorax. At the molt the defaced surfaces are restored to the fully scaled condition. The anatomy of regenerated structures was not studied. Specimens intentionally mutilated have molted within a week, regenerating the distal halves of antennæ and cerci and even the three distal segments of a rear leg. Four fertile females at least five months of age were brushed entirely free of scales. They molted in five to eight days and regained their original appearance.

TEMPERATURE RELATIONS

Thermobia can endure, without apparent injury, temperatures which will produce heat rigor in some forms. After a consideration of the environments in which the insects were trapped a temperature of 37° C. was chosen for the rearing cabinet. The first generation of firebrats reared was tested for reactions to heat in a specially devised thermal gradient, the description of which is to be published elsewhere. The results showed that these firebrats strongly preferred temperatures around 36° to 39° C. and that temperatures above 43° C. and below 32° C. were avoided. It is not to be overlooked that these firebrats might have been, to some extent, acclimated.

The high temperature which will kill in one hour was found to be about the same as that found in previous work upon the larvæ of *Pyrausta nubilalis* Hubn. and agreed with Bachmetjew's well known conclusions upon maximum temperatures for insects. Nearly full grown firebrats were exposed in small, specially devised, closed, glass chambers containing saturated sodium chloride solution which should give a humidity near 74 per cent. Ten hours of exposure at 45° C. produced no noticeable effects. A similar exposure at 47° C. killed one out of four. A ten-hour exposure at 48° C. killed all. A three-hour exposure at 48° C. killed three of four. A one-hour exposure at 49° C. likewise killed three of four.

Low temperature reactions were little studied. A few individuals were taken singly in a specially designed tube and cooled with a flow of escaping carbon dioxide, at the rate of about one degree in two minutes, from 22° C. to —2° C. and allowed to

warm again at about the same rate. The animals became wholly inert at the low temperature but recovered apparently normal activity within the hour after return to room temperature.

MOISTURE RELATIONS

Firebrats have been reared at 37° C. and 50 to 70 per cent relative humidity both with and without being given water to imbibe. More rapid growth resulted where water was given. In one experiment those reared with water weighed about 50 per cent more than those receiving none. The food was given with only such moisture as it held in air at room conditions. The insects readily eat food which is actually moistened but such is not practicable owing to molds. They also readily approach wet cotton wicks, although drops of water are avoided.

Firebrats have been reared through the life cycle from egg to egg without having access to water. The development under these conditions has been decidedly slower, and oviposition retarded and decreased.

The firebrat is evidently tolerant to a very wide range of humidity. Nymphs, newly hatched, in closed containers, over distilled water, survived several days until overcome by a condensation film. Others, hatched over potassium hydroxide solutions of saturation deficiencies calculated to give low humidities of 30 and 40 per cent, and fed but given no water, had their first molt in the usual time. Newly hatched nymphs were placed in vials with food and no water and the vials placed in a dessicating jar over a solution of magnesium chloride with an excess of the chloride. When examined at the end of three days they appeared about normally active. The chloride, according to physical tables, gives a relative humidity of near 33 per cent.

These low humidity tests were made only in closed containers. No tests were made with moving air.

FOOD HABITS

Owing to the heavy tufts of cephalic hairs the action of the mouthparts is not readily observed. Firebrats lift and carry fragments of rolled oats or eggs of their own kind in their jaws.

In the present experiments raw rolled oats and raw dried beef were the standard foods. The oats were used as they come from

the mills of the Quaker Oats Company. The beef was dried and ground. The two foods were given together without being mixed. Paper bearing a glaze was present in all the jars but was not scraped by the insects except under force of starvation.

Small trials have readily shown that starved firebrats will also devour the eggs, exuviæ, and bodies of their own kind. A gradual decline in population among growing nymphs can be attributed to cannibalism. It is probable that weak individuals are killed during ecdysis and that cannibalism serves an important biologic function in carrying the line of life over periods of adversity.

Where 100 newly hatched nymphs were fed on glazed paper only, the population gradually declined till at the end of two months but four individuals were left. These had an average body length of near 3.5 mm. or about half that in a similar group fed on oats and beef. Where beef alone was given, with, of course, glazed paper present but scarcely touched, the population of 100 declined to 51 in the first month, 25 in the second and 18 in the third.

Olfactometric data have been negative. The odour of ground rolled oats did not seem to be attractive to firebrats at a distance of eight centimeters even after two days' starvation. No marked preference was shown between the odour of oleic acid and cleaned air. Strong, positive responses to dry food particles and avoiding responses to resting drops of water, oil, etc., followed only upon direct antennal contacts.

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